PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 85/TY00P46/WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/JP2004/014576	International filing date *(day/month/year)* 28.09.2004	Priority date *(day/month/year)* 09.10.2003
International Patent Classification (IPC) or national classification and IPC H01M8/02		
Applicant TOYOTA JIDOSHA KABUSHIKI KAISHA et al.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 20 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☒	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10.11.2005	25.01.2006
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Koessler, J-L Telephone No. +49 89 2399-7217

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/JP2004/014576

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1, 2, 8-16	as originally filed
3, 3a-3c, 4-7	received on 10.11.2005 with letter of 10.11.2005
Claims, Numbers	
1-9	received on 10.11.2005 with letter of 10.11.2005
Drawings, Sheets	
1/4-4/4	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. IV Lack of unity of invention

1. ☐ In response to the invitation to restrict or pay additional fees, the applicant has:
   - ☐ restricted the claims.
   - ☐ paid additional fees.
   - ☐ paid additional fees under protest.
   - ☐ neither restricted nor paid additional fees.
2. ☒ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is
   - ☐ complied with.
   - ☒ not complied with for the following reasons:

     see separate sheet
4. Consequently, this report has been established in respect of the following parts of the international application:
   - ☒ all parts.
   - ☐ the parts relating to claims Nos. .

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-9
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations (Rule 70.7):

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Cited documents

Reference is made to the following documents:

D1: US 2002/122970 A1 (INOUE MASAJIRO ET AL) 5 September 2002 (2002-09-05)
D2: US 2003/091885 A1 (KOBAYASHI SUSUMU ET AL) 15 May 2003 (2003-05-15)
D3: US 2003/186106 A1 (FRANK DAVID ET AL) 2 October 2003 (2003-10-02)
D4: US 2002/182471 A1 (KRALICK JAMES H) 5 December 2002 (2002-12-05)
D5: US 2003/072988 A1 (FRISCH LAWRENCE EUGENE ET AL) 17 April 2003 (2003-04-17)
D6: US 2002/031698 A1 (INOUE MASAJIRO ET AL) 14 March 2002 (2002-03-14)
D7: EP-A-1 302 996 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD) 16 April 2003 (2003-04-16)

2. Amendments (Art. 34(2)b PCT)

New claim 1 has been limited to a seal structure for a fuel cell as recited in original claim wherein the back-up is formed in said separator and includes a rib having a convex and concave structure. The basis for this amendment can be found in original claim 5 and 9 as well as in fig. 5 and 6.

Original claims 4, 5, 7, 8 and 9 have been deleted.

New claim 9 which corresponds to original claim limited by the following feature "said interrupted back-up disposed at said connecting coolant passage is made from a seal material". The basis for his amendment can be found on p. 11 l. 9 and on p. 11 last line to p. 12 l. 9.

The applicant discussed documents D1-D7 on new p. 3a, b. And adapted the description to the newly filed claims (new p. 4-7).

3. Unity of invention (R. 13 PCT)

This Authority considers that there are 2 inventions covered by the new claims indicated as follows:

Claims 1-8 is directed to a seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and-said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction characterized in that said back-up is formed in said separator and includes a rib having a convex and concave structure.

Claim 9 is directed to a seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and-said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with

each other in a fuel cell stacking direction characterized in that said back-up disposed at said connecting coolant passage is made from a seal material.

The common technical features between the subject-matter of new independent claims 1 and 9 is a seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and-said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction.

These common technical features are already known from for ex. D1 (fig. 2), D2 (fig. 11, 12) D3 (fig. 3d), D4, (fig. 3, 4, 8), D5 (fig, 6a), D6 (fig. 3-5) and D7 (fig. 3).

Hence, the groups of claims are not linked by a corresponding special technical features in the sense of R. 13.2 PCT and define 2 different inventions not linked by a single general inventive concept.

The application does not meet the requirements of unity of invention as defined in Rules 13.1 and 13.2 PCT.

4. Novelty (Art. 33(2) PCT)

The present application relates to a seal structure for a fuel comprising an interrupted back-up disposed at least one of the connecting gas passage and the connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said

portion of said seal line are overlapped with each other in a fuel cell stacking direction and wherein the back-up is formed in said separator and includes a rib having a convex and concave structure or the interrupted back-up disposed at said connecting coolant passage is made from a seal material

D1 is no longer prejudicial to the novelty of new claims 1-9 because D1 disclose a back-up structure made of a seal material and disposed at the gas inlet/exhaust passages.

D2-D7 do neither describe an interrupted back-up formed in the separator itself including a rib having a convex and concave structure nor an interrupted back-up made from a seal material disposed at the connecting coolant passages as recited in new claims 1 and 9.

The amended application meets the requirements of Art. 33(2) PCT because the subject-matter of claims 1-9 is novel.

5. Inventive step (Art. 33(3) PCT)

The closest prior art is considered to be document D1.

The problem addressed in the present application is to be regarded as to provide an improved seal structure.

None of the cited documents taken alone or in combination would fairly suggest the subject-matter of new claims 1 and 9.

The amended application meets the requirements of Art. 33(3) because the subject-matter of claims 1-9 is based on an inventive step.

6. Industrial applicability (Art. 33(4) PCT)

The subject-matter of new claims 1-9 is considered to be industrially applicable.

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(amended) Claims

1. A seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction, characterized in that said back-up is formed in said separator and includes a rib having a convex and concave structure.

2. A seal structure of a fuel cell according to claim 1, wherein said back-up is disposed at said connecting gas passage between said gas passage and said gas manifold.

3. A seal structure of a fuel cell according to claim 1, wherein said back-up is disposed at said connecting coolant passage between said coolant passage and said coolant manifold.

4. A seal structure of a fuel cell according to claim 1, wherein though said gas manifold and said coolant manifold differs in width to each other, said interrupted back-up and a portion of said seal line positioned in an extension of said interrupted back-up are disposed on a same straight line.

5. A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in said separator and includes a plurality of protrusions spaced from each other.

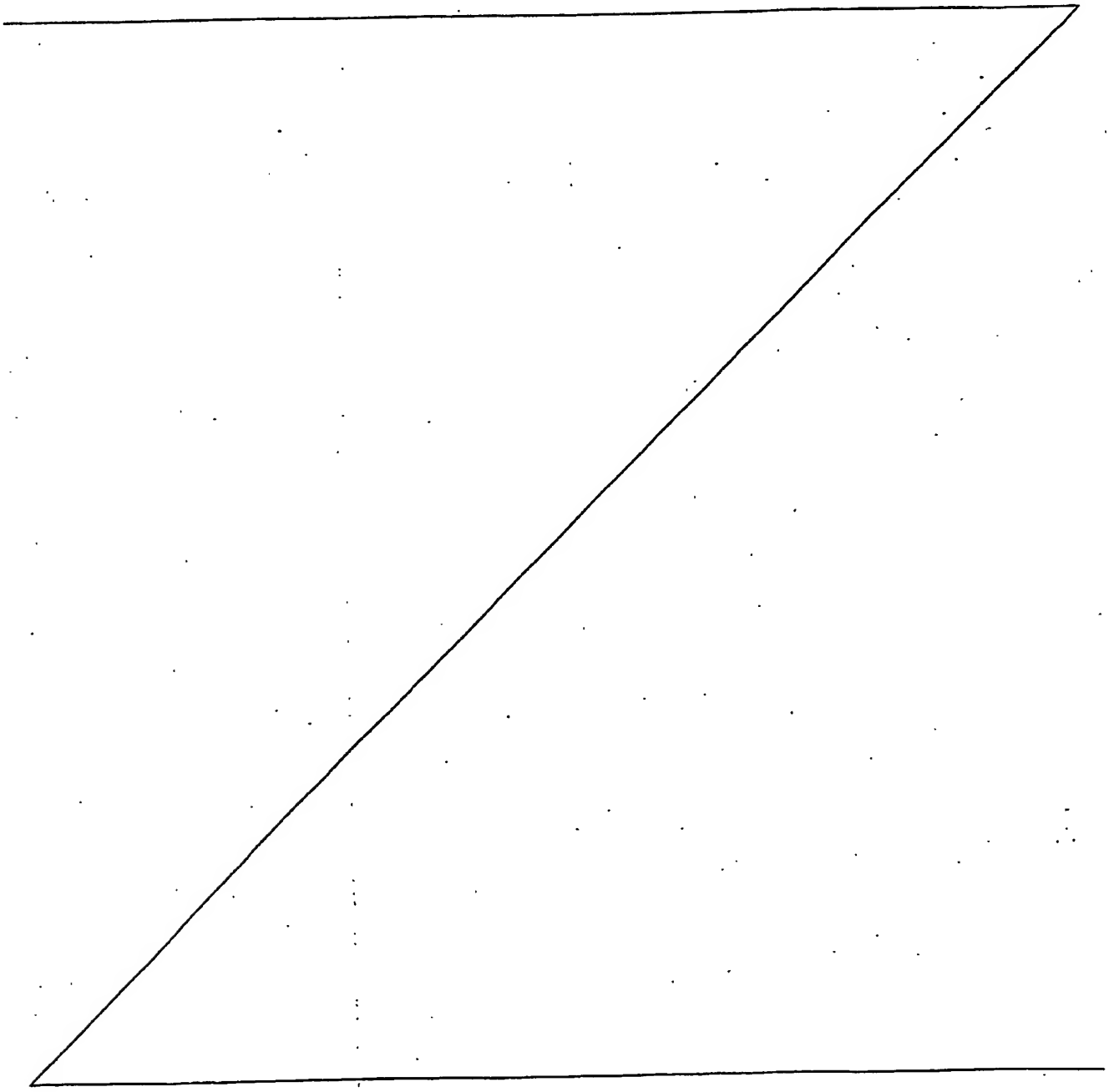
6. A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in said separator and includes a rib having a plurality of tunnels formed in said rib and spaced from each other.

7. A seal structure of a fuel cell according to claim 1, wherein an entire portion of said back-up located between adjacent separators is formed in either one separator of the adjacent separators.

8. A seal structure of a fuel cell according to claim 1, wherein a portion of said back-up located between adjacent separators is formed in one separator of the adjacent separators, and a remaining portion of said back-up located between adjacent separators is formed in the other separator of the adjacent separators.

9. A seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction, characterized in that said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

coolant manifold are different from each other, usually the gas seal line and the coolant seal line cannot be overlapped in the fuel cell stacking direction. As a result, the problem of the portion "B", that is, the problem that the seal line is bent and when the separator is deformed locally, the seal is separated from the separator to cause leakage, cannot be solved.



Document US 2003/0091885 A1 discloses an electrolyte membrane-gasket assembly for a fuel cell, including a polymer electrolyte membrane and a gasket, made of a seal material, covering the peripheral portion of the electrolyte membrane, in which the electrolyte membrane has a sequence of a plurality of through-holes in the peripheral portion, and a portion of the gasket covering one surface of the electrolyte membrane and a portion covering the other surface are connected to each other through the through-holes of the electrolyte membrane.

Document US 2003/0186106 A1 discloses a fuel cell stack comprising a plurality of fuel cells, each having an anode flow field plate, a cathode flow field plate and a membrane electrode assembly disposed between the flow field plates. The anode and cathode flow field plates have primary channels and ribs separating the primary channels. At least a portion of the anode and cathode primary channels are disposed directly opposite one another with a membrane exchange assembly therebetween and with at least some of the ribs on the anode and cathode flow field plates located directly opposite one another to sandwich the membrane exchange assembly therebetween.

Document US 2002/0182471 A1 discloses a sealing method and apparatus for a fuel cell stack that includes a stack of flow plates, a first gasket that is compatible with a coolant and a second gasket that is incompatible with the coolant. The first gasket forms a seal around a coolant manifold passageway between an adjacent pair of plates. At least one region of a particular plate may be associated with a reactant flow, and this plate may include internal passageways that extend between manifold passageways to communicate a coolant. A seal that is substantially permanent isolates the internal passageways from the regions of the fuel cell plate that may be associated with reactant flows.

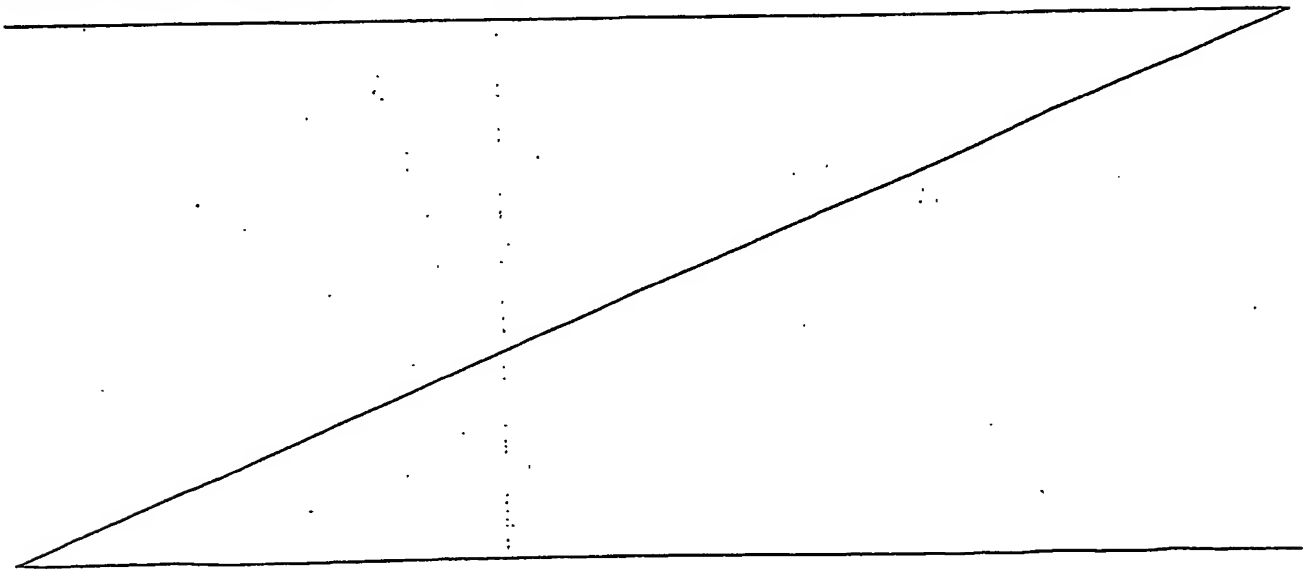
Document US 2003/0072988 A1 discloses seals for fuel cells and fuel cell stacks, wherein in a fuel cell stack assembly having a plurality of plates with grooves for

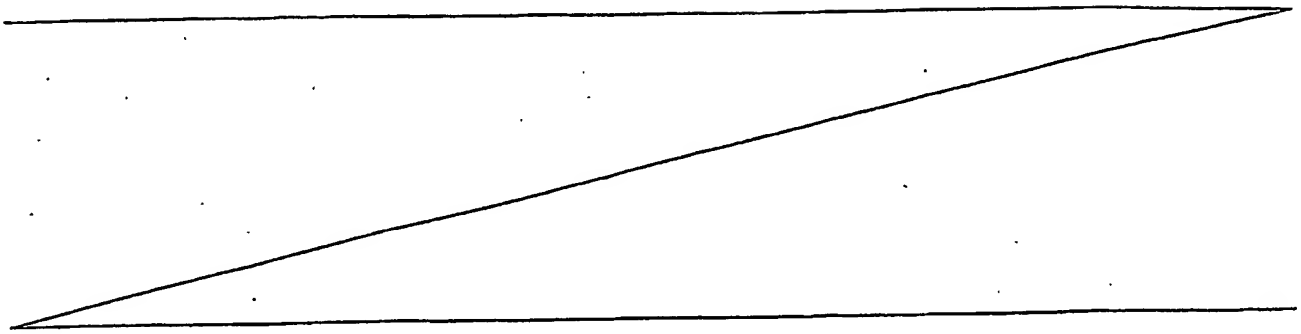
accommodating gaskets. Seals are provided between individual fuel cell plates in the fuel cell stack assembly in order to prevent leakage of gases and liquids required for operation of the fuel cell stack assembly.

Document US 2002/0031698 A1 discloses a fuel cell having sealant for sealing a solid polymer electrolyte membrane, wherein a seal contacts the projecting portion which extends from the solid polymer electrolyte membrane and which projects from the peripheries of the anode side diffusion electrode and the cathode side diffusion electrode while the membrane electrode assembly is disposed between the separators.

Document EP 1 302 996 A2 discloses a polymer electrolyte fuel cell comprising a unit cell comprising a membrane electrode assembly (MEA) comprising a polymer electrolyte membrane, a gasket covering the periphery of the electrolyte membrane, an anode and a cathode attached to the electrolyte membrane; and conductive separator plates sandwiching the MEA therebetween.

Document US 2002/0122970 A1 discloses a method for fabricating a seal-integrated separator for a fuel cell, wherein a seal-integrated separator having first to fourth seals which are integrated on both sides of the separator body is fabricated.





A first problem to be solved by the present invention is that at the gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages at the central portion of the fuel cell, one of the gas seal and the coolant seal at the opposite sides of the separator is not provided. As a result, the gas seal and the coolant seal at the opposite sides of the separator cannot operate as a back-up to each other, and sealing characteristic and stability of the seal on a backside of the interrupted seal portion are degraded.

A second problem to be solved by the present invention is that, in addition to the first problem, in the case where the width of the gas manifold and the width of the coolant manifold are different from each other, the gas seal line and the coolant seal line are not overlapped to each other, and sealing characteristic and stability of the non-overlapped portion of the seal line are degraded.

Summary of the Invention

A first object of the present invention is to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal are assured even at gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages of a central portion of the fuel cell.

A second object of the present invention is, in addition to the first object, to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal

are assured even when the a width of the gas manifold and a width of the coolant manifold are different from each other.

A seal structure of a fuel cell according to the present invention to achieve the above objects may be described as follows:

(1) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said back-up may be formed in the separator and may include a rib having a convex and concave structure.

(2) The back-up may be disposed at the connecting gas passage between the gas passage of the central portion of the fuel cell and the gas manifold.

(3) The back-up may be disposed at the connecting coolant passage between the coolant passage of the central portion of the fuel cell and the coolant manifold.

(4) The gas manifold and the coolant manifold differs form each other in width. The interrupted back-up and a portion of the seal line positioned in an extension of the interrupted back-up are arranged to be disposed on or along a same straight line.

(5) In the seal structure of a fuel cell of item (1) above, the back-up is formed in the separator and may include a plurality of protrusions spaced from each other.

(6) In the seal structure of a fuel cell of item (1) above, the back-up is formed in the separator and may include a rib having a plurality of tunnels formed in the rib and spaced from each other.

(7) In the seal structure of a fuel cell of item (1) above, an entire portion of the back-up located between adjacent separators is formed in one of either separator of the adjacent separators.

(8) In the seal structure of a fuel cell of item (1) above, a portion of the back-up located between adjacent separators is formed in one separator of the adjacent separators, and a remaining portion of the back-up located between adjacent separators is formed in the other separator of the adjacent separators.

(9) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

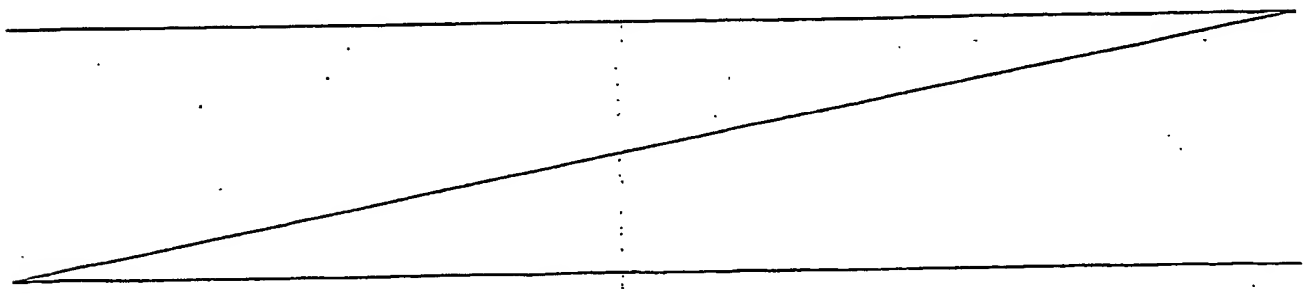
With respect to a seal structure of a fuel cell according to the present invention, the following technical advantages are obtained:

According to the seal structure of a fuel cell described in items (1)-(9) above, since the interrupted back-up is formed at at least one of the connecting gas passage and the connecting coolant passage, and the interrupted back-up and the continuous seal line located on the backside of the interrupted back-up via the separator are overlapped in the fuel cell stacking direction, the continuous seal line and the separator are backed-up or supported by the interrupted back-up in the fuel cell stacking direction. As a result, even when a gas pressure acts on the separator, the separator will not be deformed and will not be separated from the continuous seal line, and the sealing characteristic and stability of the continuous seal will be maintained well.

Further, since the back-up is interrupted, flow of gas and coolant through the back-up between the manifold and the passage at the central portion of the fuel cell is maintained well.

According to the seal structure of a fuel cell described in item (1) above, since the interrupted back-up is formed in the separator, it is easy to form the interrupted back-up, because the seal structure can be obtained only by a design change of the connecting gas passage and the connecting coolant passage of the separator.

According to the seal structure of a fuel cell described in item (4) above, since the



interrupted back-up and the seal line located in the extension of the interrupted back-up are made straight irrespective of a difference between the width of the gas manifold and the width of the coolant manifold, the problem of a stress concentration at the corner of the seal line which is caused in a bent seal line is eliminated, and a good sealing characteristic and stability are obtained over the entire portion of the straight seal line.

Brief Description of the Drawings

The seal structure of a fuel cell according to the present invention will now be explained with reference to the accompanying drawings, in which:

FIG. 1 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional view of the seal structure of FIG. 1 taken along line II-II;

FIG. 3 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a second embodiment of the present invention;

FIG. 4 is a cross-sectional view of the seal structure of FIG. 3 taken along line IV-IV;

FIG. 5 is a cross-sectional view of one example of a back-up of the seal structure of FIG. 3 taken along line V - V;

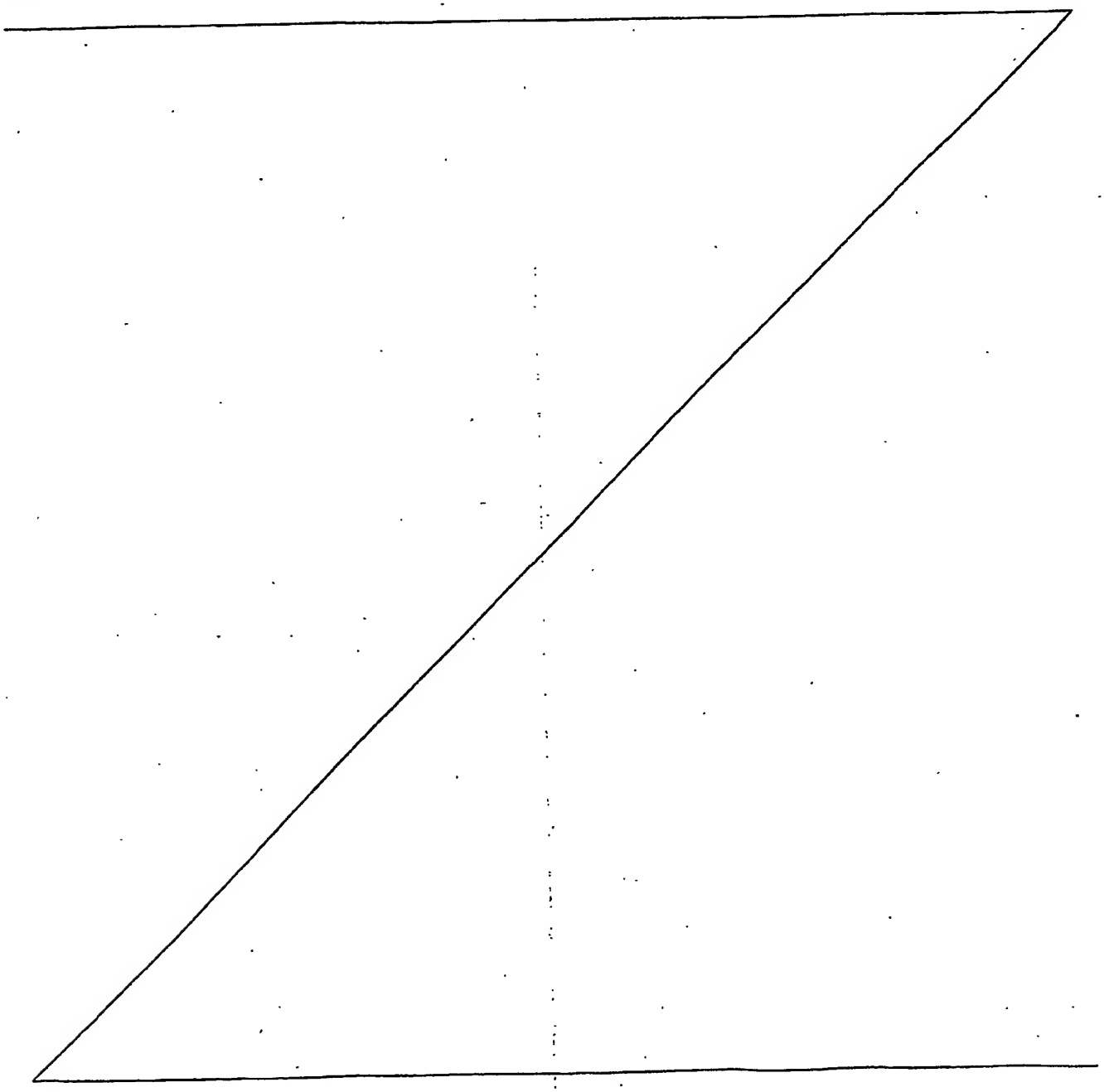
FIG. 6 is a cross-sectional view of another example of the back-up of the seal structure of FIG. 3 taken along line V - V;

FIG. 7 is a side elevational view of a fuel cell stack including the seal structure according to the present invention;

FIG. 8 is a front elevational view of a front surface and a rear surface of a seal structure of a conventional fuel cell; and

FIG. 9 is a cross-sectional view of the seal structure of FIG. 8 taken along line IX-

coolant manifold are different from each other, usually the gas seal line and the coolant seal line cannot be overlapped in the fuel cell stacking direction. As a result, the problem of the portion "B", that is, the problem that the seal line is bent and when the separator is deformed locally, the seal is separated from the separator to cause leakage, cannot be solved.



Document US 2003/0091885 A1 discloses an electrolyte membrane-gasket assembly for a fuel cell, including a polymer electrolyte membrane and a gasket, made of a seal material, covering the peripheral portion of the electrolyte membrane, in which the electrolyte membrane has a sequence of a plurality of through-holes in the peripheral portion, and a portion of the gasket covering one surface of the electrolyte membrane and a portion covering the other surface are connected to each other through the through-holes of the electrolyte membrane.

Document US 2003/0186106 A1 discloses a fuel cell stack comprising a plurality of fuel cells, each having an anode flow field plate, a cathode flow field plate and a membrane electrode assembly disposed between the flow field plates. The anode and cathode flow field plates have primary channels and ribs separating the primary channels. At least a portion of the anode and cathode primary channels are disposed directly opposite one another with a membrane exchange assembly therebetween and with at least some of the ribs on the anode and cathode flow field plates located directly opposite one another to sandwich the membrane exchange assembly therebetween.

Document US 2002/0182471 A1 discloses a sealing method and apparatus for a fuel cell stack that includes a stack of flow plates, a first gasket that is compatible with a coolant and a second gasket that is incompatible with the coolant. The first gasket forms a seal around a coolant manifold passageway between an adjacent pair of plates. At least one region of a particular plate may be associated with a reactant flow, and this plate may include internal passageways that extend between manifold passageways to communicate a coolant. A seal that is substantially permanent isolates the internal passageways from the regions of the fuel cell plate that may be associated with reactant flows.

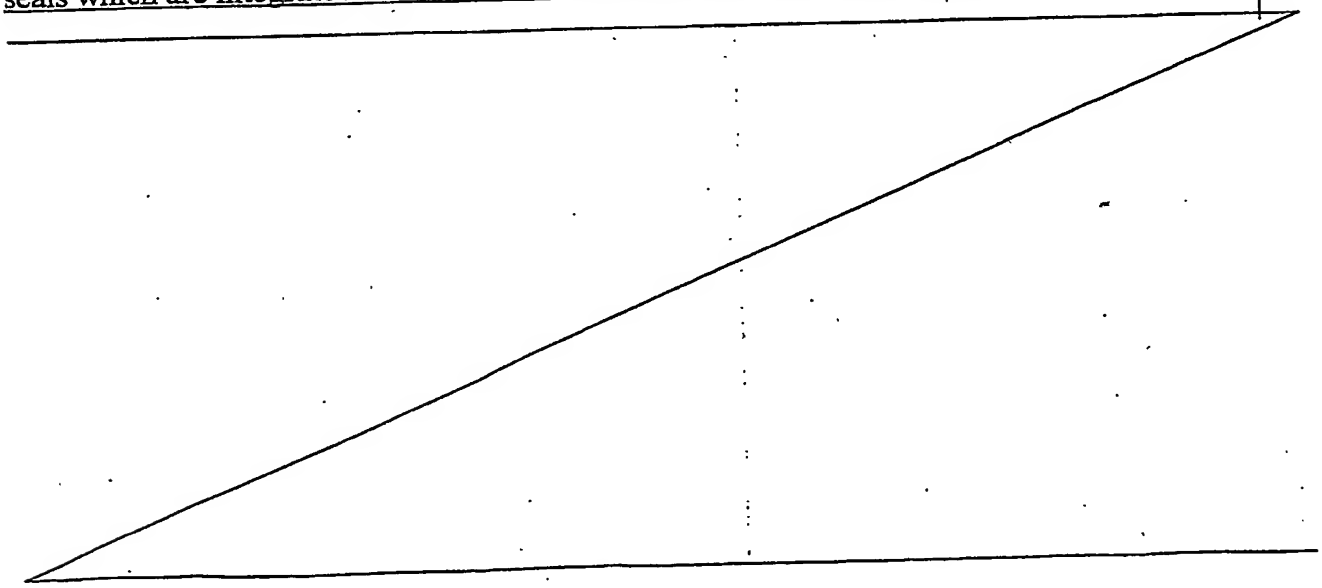
Document US 2003/0072988 A1 discloses seals for fuel cells and fuel cell stacks, wherein in a fuel cell stack assembly having a plurality of plates with grooves for

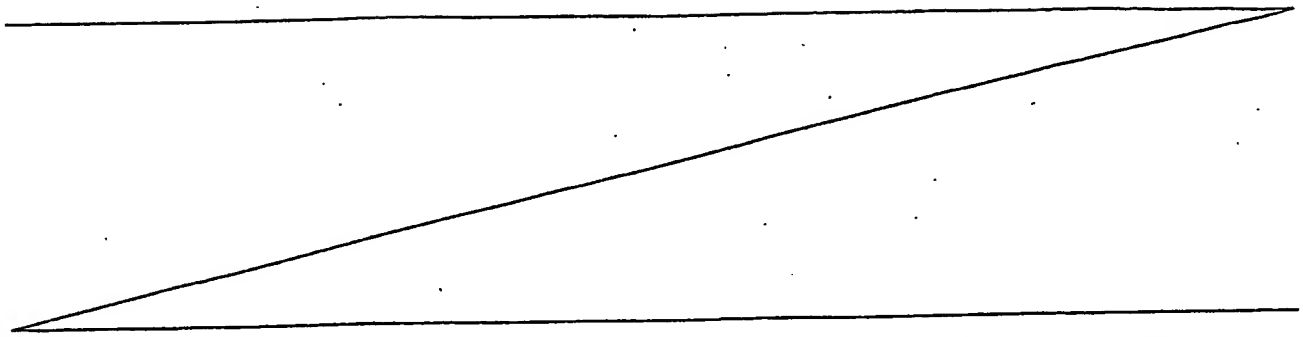
accommodating gaskets. Seals are provided between individual fuel cell plates in the fuel cell stack assembly in order to prevent leakage of gases and liquids required for operation of the fuel cell stack assembly.

Document US 2002/0031698 A1 discloses a fuel cell having sealant for sealing a solid polymer electrolyte membrane, wherein a seal contacts the projecting portion which extends from the solid polymer electrolyte membrane and which projects from the peripheries of the anode side diffusion electrode and the cathode side diffusion electrode while the membrane electrode assembly is disposed between the separators.

Document EP 1 302 996 A2 discloses a polymer electrolyte fuel cell comprising a unit cell comprising a membrane electrode assembly (MEA) comprising a polymer electrolyte membrane, a gasket covering the periphery of the electrolyte membrane, an anode and a cathode attached to the electrolyte membrane; and conductive separator plates sandwiching the MEA therebetween.

Document US 2002/0122970 A1 discloses a method for fabricating a seal-integrated separator for a fuel cell, wherein a seal-integrated separator having first to fourth seals which are integrated on both sides of the separator body is fabricated.





A first problem to be solved by the present invention is that at the gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages at the central portion of the fuel cell, one of the gas seal and the coolant seal at the opposite sides of the separator is not provided. As a result, the gas seal and the coolant seal at the opposite sides of the separator cannot operate as a back-up to each other, and sealing characteristic and stability of the seal on a backside of the interrupted seal portion are degraded.

A second problem to be solved by the present invention is that, in addition to the first problem, in the case where the width of the gas manifold and the width of the coolant manifold are different from each other, the gas seal line and the coolant seal line are not overlapped to each other, and sealing characteristic and stability of the non-overlapped portion of the seal line are degraded.

Summary of the Invention

A first object of the present invention is to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal are assured even at gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages of a central portion of the fuel cell.

A second object of the present invention is, in addition to the first object, to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal

are assured even when the a width of the gas manifold and a width of the coolant manifold are different from each other.

A seal structure of a fuel cell according to the present invention to achieve the above objects may be described as follows:

(1) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said back-up may be formed in the separator and may include a rib having a convex and concave structure.

(2) The back-up may be disposed at the connecting gas passage between the gas passage of the central portion of the fuel cell and the gas manifold.

(3) The back-up may be disposed at the connecting coolant passage between the coolant passage of the central portion of the fuel cell and the coolant manifold.

~~(4) The back-up may be formed in the seal.~~

~~(5) The back-up may be formed in the separator.~~

(~~6~~4) The gas manifold and the coolant manifold differs form each other in width. The

interrupted back-up and a portion of the seal line positioned in an extension of the interrupted back-up are arranged to be disposed on or along a same straight line.

~~(7) In the seal structure of a fuel cell of item (1) above, the back-up is formed in the seal made from adhesive and coated in a form of a dotted line and the back-up includes each dot of the dotted line made from adhesive. The back-up includes a plurality of non-coated portions of adhesive which are spaced from each other in a back-up extending direction.~~

~~(8) In the seal structure of a fuel cell of item (1) above, the seal is made from a gasket (e.g., a rubber gasket) and the back-up is formed in the seal. The back-up includes a plurality of grooves or concaves (concavities) in a gasket material which are spaced from each other in a back-up extending direction.~~

~~(9) In the seal structure of a fuel cell of item (1) above, the back-up is formed in either one of the seal and the separator and may include a rib having a convex and concave structure.~~

(~~10~~5) In the seal structure of a fuel cell of item (1) above, the back-up is formed in ~~either one of the seal and~~ the separator and may include a plurality of protrusions spaced from each other.

(~~11~~6) In the seal structure of a fuel cell of item (1) above, the back-up is formed in ~~either one of the seal and~~ the separator and may include a rib having a plurality of tunnels formed in the rib and spaced from each other.

(~~12~~7) In the seal structure of a fuel cell of item (~~5~~1) above, an entire portion of the back-up located between adjacent separators is formed in one of either separator of the adjacent separators.

(~~13~~8) In the seal structure of a fuel cell of item (~~5~~1) above, a portion of the back-up located between adjacent separators is formed in one separator of the adjacent separators,

and a remaining portion of the back-up located between adjacent separators is formed in the other separator of the adjacent separators.

(9) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

With respect to a seal structure of a fuel cell according to the present invention, the following technical advantages are obtained:

According to the seal structure of a fuel cell described in items (1)-(~~13~~9) above, since the interrupted back-up is formed at at least one of the connecting gas passage and the connecting coolant passage, and the interrupted back-up and the continuous seal line located on the backside of the interrupted back-up via the separator are overlapped in the fuel cell stacking direction, the continuous seal line and the separator are backed-up or supported by the interrupted back-up in the fuel cell stacking direction. As a result, even when a gas pressure acts on the separator, the separator will not be deformed and will not

interrupted back-up and the seal line located in the extension of the interrupted back-up are made straight irrespective of a difference between the width of the gas manifold and the width of the coolant manifold, the problem of a stress concentration at the corner of the seal line which is caused in a bent seal line is eliminated, and a good sealing characteristic and stability are obtained over the entire portion of the straight seal line.

Brief Description of the Drawings

The seal structure of a fuel cell according to the present invention will now be explained with reference to the accompanying drawings, in which:

FIG. 1 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional view of the seal structure of FIG. 1 taken along line II-II;

FIG. 3 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a second embodiment of the present invention;

FIG. 4 is a cross-sectional view of the seal structure of FIG. 3 taken along line IV-IV;

FIG. 5 is a cross-sectional view of one example of a back-up of the seal structure of FIG. 3 taken along line V - V;

FIG. 6 is a cross-sectional view of another example of the back-up of the seal structure of FIG. 3 taken along line V - V;

FIG. 7 is a side elevational view of a fuel cell stack including the seal structure according to the present invention;

FIG. 8 is a front elevational view of a front surface and a rear surface of a seal structure of a conventional fuel cell; and

FIG. 9 is a cross-sectional view of the seal structure of FIG. 8 taken along line IX-